Mobile Source Modeling Protocol dated 3/13/2000

Mobile Source Emissions Inventory Protocol
PM10 SIP Development

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Mobile Source Emissions Inventory Protocol
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Overview

The purpose of this mobile source emissions protocol is to define the process for evaluating vehicle emissions to be used in developing the Salt Lake County and Utah County PM10 Section of the State Implementation Plan. ~~The Mobile Source Emissions Inventory Protocol will outline what, how and by whom mobile source emissions information will be produced.~~ The Wasatch Front Regional Council (WFRC) and Mountainland Association of Governments (MAG), the two Metropolitan Planning Organizations for the urbanized areas, will be the primary on-road mobile source emission inventory providers. The protocol will provide a description of the procedures used, the principal inputs and the data to be provided in the development of the PM-10 SIP. The document is written for use by the team preparing the SIP and for knowledgeable reviewers.

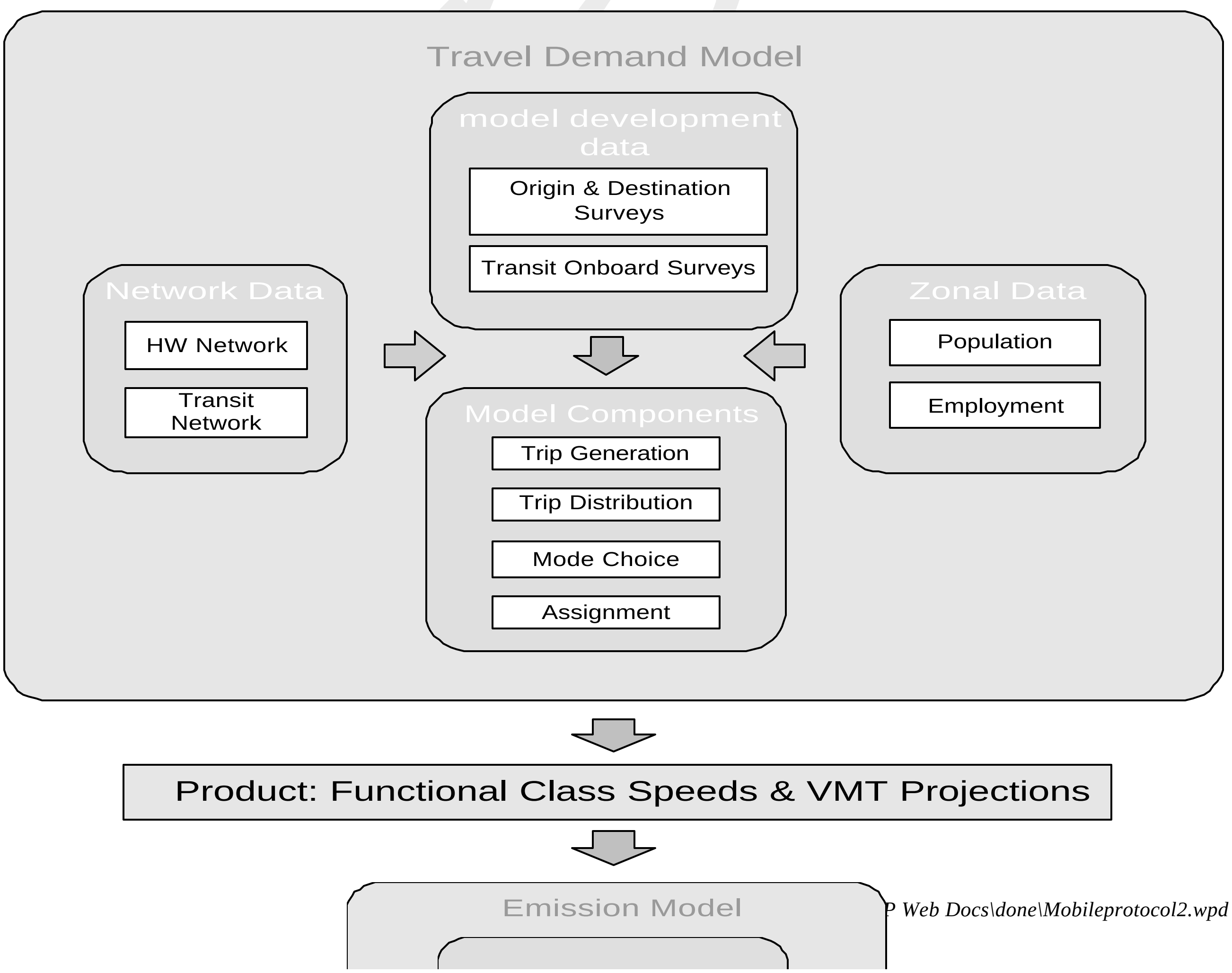
The protocol is divided into two principal sections. The first section will address the methods used to estimate the volume and speeds of travel. The second will address the procedures used to estimate per mile emission factors. All model and data sets utilized will be fully documented and copies archived in electronic and paper form. A list of data resources used to generate on-road vehicle emissions is provided in Appendix A.

WFRC is responsible for transportation planning and Air Quality Conformity in Salt Lake, Weber, and Davis Counties. MAG is responsible for air quality analysis in Summit, Utah, and Wasatch Counties. It also is responsible to create a conforming Long Range Transportation plan from which a Transportation Improvement Program for urbanized Utah County is taken.

The Mobile Source Emissions Inventory for the 1996 base year and the future projections will be derived from projections of daily vehicle miles of travel and speeds which are estimated using a travel demand forecasting model and from a mobile source emission factor model which estimates emission rates for vehicles. The basics of developing the emissions are given by the following equation. ~~The~~ Figure 1 ~~following graphic~~ summarizes the steps in the process.

Study Area
The study area includes Weber, Davis, Salt Lake, and Utah Counties with portions of Box Elder, Cache, Rich, Tooele, Morgan, Summit, Juab, Sanpete, and Wasatch Counties. The first four of these counties have four different I/M programs. Salt Lake and Utah Counties are the designated non-attainment areas for PM10, but the Division of Air Quality recommends analyzing a larger study area to better understand the conditions that lead to PM10 formation in the two non-attainment counties. Portions of the study area outside the WFRC and MAG travel model boundaries, which includes Salt Lake, Davis, Weber, and Utah Counties, will be referred to as “rural” areas in this document.

Figure 1 - Vehicle Emission Estimates



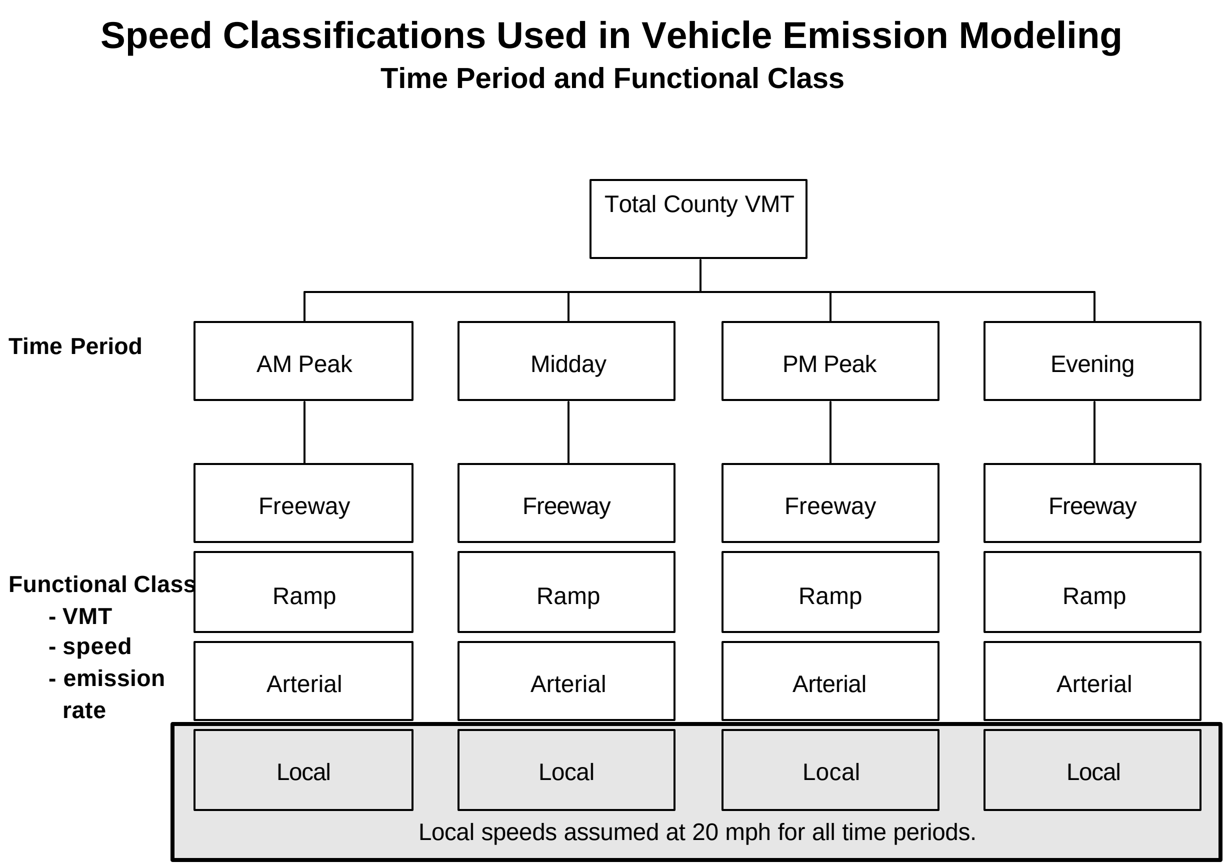
Emission Rate (gram/mile) x Vehicle Miles Traveled VMT (miles/day) = Emissions (gram/day)

VMT and Speed Estimates

Vehicle miles of travel (VMT) and travel speeds, representative of variations in daily traffic conditions and highway facility functional class, will be obtained from the travel models used by Wasatch Front Regional Council (WFRC) and Mountainlands Association of Governments (MAG). The travel model data is representative of traffic in the four urbanized counties: Weber, Davis, Salt Lake, and Utah. The VMT data for these four urbanized counties will be calibrated to UDOT's 1996 Highway Performance Monitoring system (HPMS) data.

For the other rural counties within the study area, UDOT will provide the VMT data for the 1996 baseline inventory, and the projection years. WFRC and MAG will assist UDOT as needed with VMT growth factors for projecting rural traffic volumes. The functional classes used will be freeways, ramps, arterials, and local facilities. The traffic conditions used will be AM peak, mid-day, PM peak, and ~~Free Flow~~ Evening. Combining the functional classes and traffic conditions produces the following 13 speed conditions for each county as illustrated in Figure 2.

Figure 2



~~Freeway-AM~~	~~Ramp-AM~~	~~Arterial-AM~~	~~Local-AM (20mph)~~
~~Freeway-Mid~~	~~Ramp-Mid~~	~~Arterial-Mid~~	~~Local-Mid (20 mph)~~
~~Freeway-PM~~	~~Ramp-PM~~	~~Arterial-PM~~	~~Local-PM (20 mph)~~
~~Freeway-FF~~	~~Ramp-FF~~	~~Arterial-FF~~	~~Local-FF (20 mph)~~

Note that 20 mph will be the assumed average travel speed under all conditions for local streets since local class facilities are not modeled directly as part of the travel model network. WFRC and MAG have historically used 20 mph as the local model speed. The basis for this is that posted speeds on local roads is 25 mph. Considering stops and other delays, 20 mph is a reasonable average speed. The local speed is assumed constant during all time periods because congestion on local streets is uncommon.

The VMT and speed resulting from each time period will depend on the number of vehicle trips assigned for that time period. The percentage of trips for each time period will vary by trip purpose and by county. The percentages in Table-1 below are ~~will be determined by the MPO's~~ based on data from the 1993 Home Interview Survey ~~and national trends~~. Trip purposes "commercial" (COM) and "through" (THRU) are not sampled in the Home Interview Survey. These two trip types will be allocated to the four time periods according to the percentages for NHB and IXXI trips respectively. The four time periods shown in Table 1 are defined as follows:

AM Peak	-	3 hours, 6:00 am to 9:00 am
Midday	-	6 hours, 9:00 am to 3:00 pm
PM Peak	-	3 hours, 3:00 pm to 6:00 pm
~~Free Flow~~ Evening*	-	12 hours, 6:00 pm to 6:00 am

*During the ~~hours from midnight~~ ~~Free Flow~~ Evening time period ~~to 6:00 am it is reasonable to assume that~~ *XX%* of the ~~Free Flow~~ Evening VMT occurs between the hours from midnight to 6:00 am ~~is distributed evenly over this seven-hour period~~. ***[Need 24-hour traffic count data from UDOT to determine early AM traffic]***

Table 1

Ogden Area: Percent of trips by purpose and time of day								
	AM		Mid-day		PM		Evening	
Purpose	From Home	To Home	From Home	To Home	From Home	To Home	From Home	To Home
HBW	33%	1%	9%	8%	4%	24%	9%	11%
HBO	*14%*	*2%*	*13%*	*15%*	*11%*	*17%*	*10%*	*17%*
NHB	*7%*	*NA*	*53%*	*NA*	*26%*	*NA*	*14%*	*NA*
IXXI	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*
COM	*6%*	*NA*	*40%*	*NA*	*26%*	*NA*	*28%*	*NA*
THRU	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*

Salt Lake Area: Percent of trips by purpose and time of day								
	AM		Mid-day		PM		Evening	
Purpose	From Home	To Home	From Home	To Home	From Home	To Home	From Home	To Home
HBW	39%	1%	9%	7%	2%	25%	6%	11%
HBO	*15%*	*2%*	*13%*	*13%*	*10%*	*16%*	*13%*	*20%*
NHB	*7%*	*NA*	*51%*	*NA*	*26%*	*NA*	*16%*	*NA*
IXXI	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*
COM	*6%*	*NA*	*40%*	*NA*	*26%*	*NA*	*28%*	*NA*
THRU	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*

MAG Area: Percent of trips by purpose and time of day								
	AM		Mid-day		PM		Evening	
Purpose	From Home	To Home	From Home	To Home	From Home	To Home	From Home	To Home
HBW	33%	1%	13%	9%	4%	23%	6%	13%
HBO	*13%*	*2%*	*14%*	*15%*	*11%*	*16%*	*12%*	*19%*
NHB	*5%*	*NA*	*49%*	*NA*	*27%*	*NA*	*19%*	*NA*
IXXI	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*
COM	*6%*	*NA*	*40%*	*NA*	*26%*	*NA*	*28%*	*NA*
THRU	*20%*	*NA*	*29%*	*NA*	*26%*	*NA*	*25%*	*NA*

Trip Purpose abbreviations:

HBO - Home Based Other
NHB - Non-Home Based
HBW - Home Based Work
COM - Commercial
IXXI - Internal/External, External/Internal
THRU - Through

Rural county VMT will be allocated to the four time periods based on the percentage of urban area VMT in each time periods.

Vehicle Miles Traveled (VMT) data used will be derived from two sources. The 1996 base year data will come from UDOT Highway Performance Monitoring System (HPMS). The data will be adjusted for weekday, weekend, and for time of day conditions. Projected VMT for years 2000 to 2030, will be derived from travel demand models. ~~Daily traffic and travel speeds will be developed for different highway facility functional classes. The functional classes used will be freeways, ramps, arterials, and local facilities.~~

~~Estimates of daily VMT by class as well as peak and off-peak speeds will be developed and daily estimates of mobile source emissions will be made for each county. For modeling purposes the VMT will be broken into four time periods: AM peak, mid-day, PM peak, and free flow. The VMT by time period will be used to estimate the distribution of emissions by hour over a 24 hour period. The travel models also allow for estimation of VMT by individual road segments which will be used to summarize mobile source emissions by a grid structure for use in the dispersion models.~~

Urban Travel Demand Models

Urban travel demand forecasting models support the urban transportation planning process. A travel model is a series of analytical techniques used to predict demand for transportation facilities and services. Travel modeling involves estimating the impacts of various transportation facility changes and/or socio-economic changes on travel behavior.

The model can forecast travel behavior changes when new highway capacity or transit system improvements are made. In addition, the impacts of transportation demand or control measures such as High Occupancy Vehicle (HOV) lanes or raising the price of central business district parking can be predicted. Models also predict changes in travel demand resulting from socio-economic changes such as the number of people, income levels, and the spatial distributions of households and employment. The forecasting process provides estimates such as the number of vehicles using future freeways, the volume of passengers on express bus services or light rail.

Travel demand models were created to evaluate existing and potential transportation system needs such as new highway or transit facilities. In the course of this analysis impacts such as mobile source emissions can be estimated and quantified.

Travel demand models are capable of estimating changes associated with a variety of alternatives. These alternatives may include: capital improvements such as new highway capacity, transit service enhancements, a network of pedestrian and bike trails, policy initiatives such as changes in population distribution or transportation pricing, or a combination of the alternatives.

WFRC and MAG are in the midst of a significant transportation model update at the time of the PM-10 SIP development process. The 1996 base year travel models runs will use WFRC/MAG data sets and procedures as they exist on March 1, 2000. The 1996 modeled VMT is controlled to UDOT's HPMS values by functional class. Projection years will use the May 1, 2000 version of the travel model which will include an upgraded mode choice model. Projection year VMT will be adjusted using the HPMS/model VMT functional class factors determined for 1996.

The regional travel model as applied can be described as a four period traffic assignment approximating average annual weekday conditions. Adjustment factors are used to correct the model VMT to the winter season.

Travel Demand Model Data Sets & Components

The primary inputs to the modeling process are data sets describing the characteristics of the transportation system (commonly referred to as networks) and existing or future population and employment.

Highway Network and Characteristics

Highway networks describe the location of streets and highways other than local streets, their capacities, and speeds. The data is in GIS format as a set of links and nodes. A node represents a point on the highway network and could be an intersection of two or more streets, an access point where TAZ centroids are connected to the highway network, or a point along a street where the characteristics of the facility change such as the number of lanes, or the posted speed. Links are defined by two nodes. Links represent highway segments and have attributes such as functional class, distance, speed, capacity, and volume. The inventory of current network characteristics is updated regularly based on local data as well as the FHWA Highway Performance Monitoring System (HPMS).

Initial inventories and model calibration will be based on a 1996 network. MAG and WFRC have collaborated to develop a single 1996 highway network covering Weber, Davis, Salt Lake, and Utah Counties.

For future years WFRC and MAG maintain Long Range Plans (LRP) and Transportation Improvement Programs (TIP) which describe improvements to the highway and transit networks. The LRP's and TIP's will be the basis for future year networks used in projecting emissions for 2000 and beyond. Combined networks for future years will be developed as part of this and related planning efforts.

Functional Classification

The speed and capacity of streets and highways varies significantly according to the function the facility performs. Modeled facility speeds are critical to the projection of vehicle emissions.

The FHWA Functional Classification System defines the role that each street, road and highway will play in moving traffic from trip origins to destinations. This data is compiled in accordance to the Highway Functional Classification – Concepts, Criteria & Procedures –1989 by USDOT, FHWA.

Each auto trip has two separate needs, access to transportation facilities at its origin and destination points, and mobility between them. Access is best provided by streets with driveways and parking convenient to origin or destination of each traveler. Mobility is best provided by controlled access highways where there is minimum interference with the main traffic flow from side traffic. Since it is impossible to build a freeway between each origin and destination a compromise is needed, one that will provide the best practical balance between serving access and mobility.

Highway facilities are grouped into four functional classes: ~~The result is separate VMT and speed projections for~~ freeways, ramps, arterials and locals. In combination, the network formed by these various functional classifications accommodates the highway travelers' needs.

The best providers of mobility are freeways which provides full control of access, allowing smooth flow of through traffic with minimum disruptions by traffic entering or leaving the system. Freeway on and off ramps are a special class of freeway facilities.

Principal Arterials are designed to serve mainly a mobility role but still allow access to many bordering activities. Minor Arterials connect with and augment the Principal Arterials to carry mobility-oriented traffic between smaller areas and allow an even greater degree of access. Collectors connect scattered developments and suburban neighborhoods and provide access to activities along their routes. The ~~emission projections~~ travel characteristics (especially speed and function) for principal and minor arterials and collectors are very similar and therefore these functional classes are combined into the single category "arterials".

Finally, Locals principally provide access to roadside activities, homes, stores, business locations, etc. Local streets are not specifically coded as part of the transportation network. To do so would require coding each driveway as an access point to Local streets, and obtaining specific trip making characteristics for each home or business served by each driveway. A more reasonable level of detail is to aggregate trip making behavior on a Traffic Analysis Zone (TAZ) basis which will be discussed later. A "Centroid Connector" is an artificial link coded into the network for TAZ trips to access the transportation network at the arterial level. Centroid connectors simulate the function of Local streets, but are not a virtual representation of Local streets in terms of distance, capacity, volume or speed.

Speeds

Emission rates vary with the speed of vehicle. Speeds vary across functional classes and vary according to the degree of congestion. The free flow speeds (or input speeds) used in the model are capped at empirical values which are ~~based on posted speeds and speed studies~~ derived from Highway Capacity Manual methods based on functional class, number of lanes, and area type. The HCM based speeds are typically somewhat less than posted speeds. WFRC and MAG are engaged in "floating car" speed studies at the time of this writing. Historically, freeway free flow speeds used in the model have been an issue. WFRC and MAG hope to have sufficient data to validate freeway free flow speeds prior to modeling 1996 base year conditions. Free flow speeds for other facility types will also be checked within the same time constraints.

Congested ~~speeds~~ travel times for each link are estimated by the travel ~~demand forecasting~~ model based on the ratio of estimated volume to capacity. Link level travel times are used by the travel model to distribute and assign trips as will be discussed later. For vehicle emission estimation purposes, aggregate congested speeds will be estimated for each of the four classes of facilities and for AM-peak, mid-day, PM-peak, and ~~free-flow~~ evening periods. Vehicle Hours of Travel (VHT) and Vehicle Miles of Travel (VMT) are tallied by county, functional class, and time period and a corresponding speed is calculated (VMT/VHT).

Capacity

The 1994 Highway Capacity Manual is used to estimate capacity. The functional class and number of lanes determine the highway network facility's capacity. A summary of the capacities used is given in Table 2 ~~below~~.

Table 2
Speed and Capacity Values

Functional Classification		Speed (mph)			Capacity (cars per lane per hour)[b]		
Freeways		60			1600		
Ramps - On-ramps[a]		35			1200		
Ramps - Off-ramps		40			1525		
Two-Lane Highways		58			675		
Multilane Highways		50			1300		
Centroid Connectors		20			3500		
Arterial/Collector	*No. of Lanes*	*Suburban Fringe*	*Suburban*	*Urban*	*Suburban Fringe*	*Suburban*	*Urban*
Principal Arterial	1	38	31	28	550	500	450
	2	40	33	30	600	550	500
	3-4	41	34	31	675	625	575
Minor Arterial	1	34	27	24	500	450	400
	2	36	29	26	550	500	450
	3-4	37	30	27	625	575	525
Collector	1	32	25	22	450	400	400
	2	34	27	24	500	450	450
	3-4	35	28	25	575	525	525

(a)Subtract 10 mph for loop or hook ramps.
(b)For capacity restraint purposes network capacity is level of service C service volume.

Transit Network

The Transit network is a representation of the existing or proposed transit system. The modeled bus system includes service characteristics, such as bus headways (frequency), stops, and transfer opportunities. Transit networks are generally built "on top of" highway networks. Bus routes are described by the nodes of the highway network that the bus would pass over. For transit facilities such as bus way or grade-separated rail lines that do not use the street system, transit only links and nodes are added to the underlying highway network.

Transit access links are added to describe the walk or drive access to transit stations or bus stops. Transit access links are necessary to accurately represent the travel impedance of transit trips. Impedance is a measure of the resistance to traveling. The impedance measure used in the WFRC and MAG travel model is time.

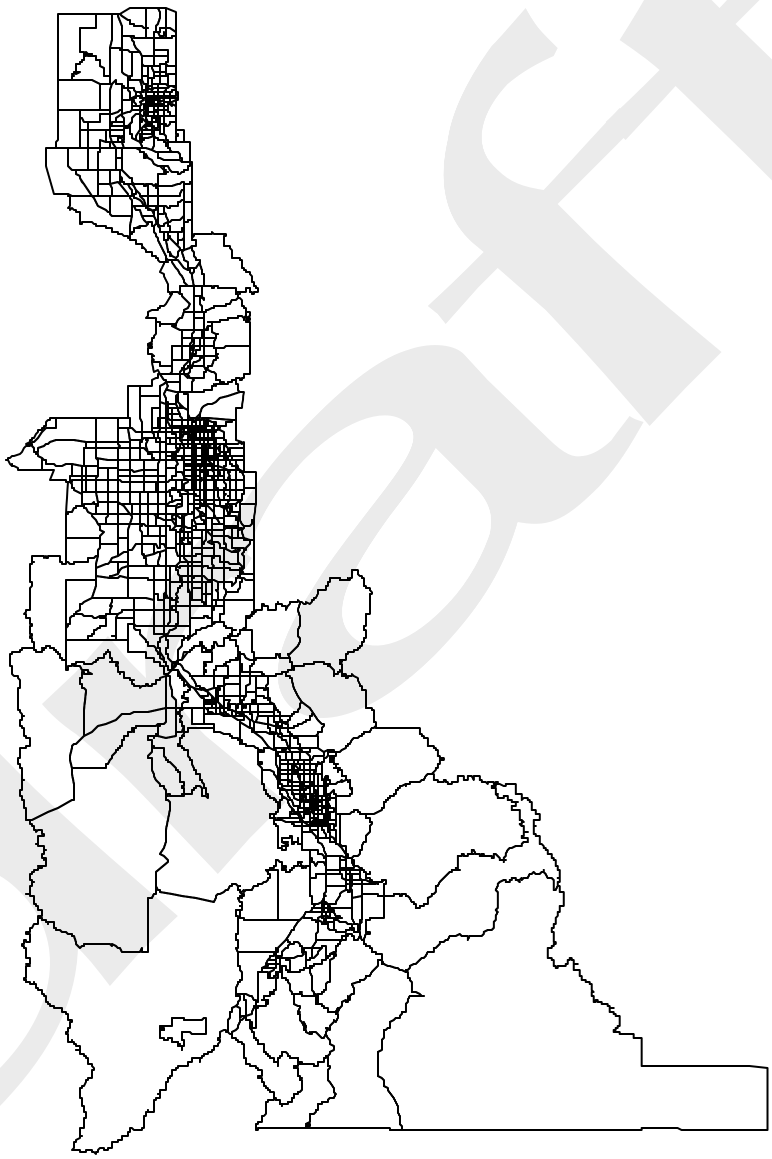
As is the case for highways MAG and WFRC have developed transit networks which represent the service provided by UTA in 1996. The networks include bus service provided within the three urbanized areas as well as the service between the areas.

Future year networks will be based on the Long Range Plans developed by MAG and WFRC. These Plans will include existing and future the bus service and rail lines.

Zonal Data

Travel models create a unique spatial framework for describing travel demand. The study area is subdivided into small geographic units called Traffic Analysis Zones (TAZ). The zonal systems to be used for this effort will be a 602-zone system for the Salt Lake Area, a 239-zone system for the Ogden Area, and a 349-zone system for the Provo-Orem Area. Zones are not bisected by census tract boundaries, thus each of the area's census tracts contains one or more TAZ. A map of the zones is shown as Figure 3.

Figure 3
TAZ Map, WFRC and MAG Regional Travel Model



Population & Employment

For 1996, economic and demographic data by TAZ are estimated by WFRC and MAG using information provided by cities and counties as well as data provided by the Department of Workforce Services. The data for the WFRC area are provided in the 1995 Surveillance of Socio-Economic Characteristics Report. The 1995 report provides data as of December 31, 1995 which will be the closest data for the 1996 winter episodes which will form the basis of SIP development. The Department of Workforce Services annually provides detailed current employment data.

Future year projections of socio-economic data begin with control totals provided by the Governors Office of Planning and Budget (GOPB). The GOPB projections are the State's official demographic estimates and forecasts are published for each county in the State. The projections are shown in the 2000 Economic Report to the Governor. Each MPO allocates the population, households, and employment to TAZ. The allocation to zones is done on the basis of local master plans and in conjunction with local planners. Detailed projections are made in 5 year increments beginning in 2000 and extending to 2030. Estimates for intermediate years are interpolated from the 5 year projections.

Household data has been stratified by (1) the number of persons per household and (2) by the number of vehicles used by the household. The model applies a set of equations to this data to calculate the expected number of person-trips for each household based on ***household size/number of vehicles*** combination totals for each TAZ.

The Four-Step Process

Most metropolitan areas throughout the country use a similar approach to simulate regional travel behavior. This approach is known as the "four-step process" because it consists of four distinct procedures: Trip Generation, Trip Distribution, Mode Choice, and Traffic Assignment. The travel demand models are updated regularly in an incremental fashion and the models used for the PM10 SIP update will be the models as they exist on March 1, 2000.

Step One - Trip Generation

The first step in the process is to determine the number of daily trips that take place or will take place at future intervals in the planning period. The trip generation procedure estimates the number of trips to and from each TAZ in the study area.

The trip generation model estimates the number of trips, both motorized and non-motorized, produced and attracted at each zone. These include internal-external and external-internal trips. Eight trip purposes are defined in the trip generation model.

Home-based work (HBW)
Home-based other (HBO)
Home-based school (HBSC)
Home-based shopping (HBSH)
Home-based personal business (HBPB)
Non-home-based, work-related (NHBW)
Non-home-based, non-work-related (NHBN)
Commercial (COM)
Through (THRU) - *THRU trips are not a product of trip generation, but are determined separately based on traffic counts of vehicles that have a starting point and ending point outside the modeled area.*

Trip generation and trip distribution for the home based trip purposes is done on a production/attraction basis. That is, all home based trips are assumed to be produced at the home end of the trip and attracted to the non-home end. For example, a trip from home to work and its corresponding trip from work to home would be considered to have 2 home based work (HBW) productions at the home end and 2 HBW attractions at the work end. The use of productions and attractions rather than origins and destinations is a more rational method of trip generation, distribution and mode choice.

Non-home based (NHB), and Commercial trips are generated and distributed on an origin/destination basis.

The trip production model is a cross classification household trip rate model. The households are classified by household size and car ownership. Four car ownership classes (0-car, 1-car, 2-car and 3+car) and six household size categories (1-person, 2-person, 3- person, 4-person, 5-person, and 6+person) were defined. The trip rates for each class of households were determined based on the home interview survey. Aggregated trip records were used to derive the trip rates since the process is much simpler and the derived rates are more reliable.

It should be noted that for the Non-Home Based trip purpose, the trip production rates are only used for calculating the total trips generated for the entire region, not for determining the trips generated from individual zones. The reason is that the number of Non-Home Based trips generated from a zone is not related to the number of households in that zone. Instead, it relates to the development characteristics of the zone such as employment, area type, etc. For each zone, the number of Non-Home Based trip origins is, in most cases, approximately equal to the number of Non-Home Based trip destinations. Therefore, trip end models are used for the non-home based purpose. Namely, the model estimates the total trip ends (trip origins plus destinations) at a zone and splits the trip ends equally into productions (origins) and attractions (destinations). The development of the trip end model is the same as the trip attraction models discussed below.

The trip attraction model is a regression model using zonal trip attraction and socio-economic data. The variables considered in the regression analysis include:

- Population
- Total dwelling units
- Single family dwelling units
- Multi-family dwelling units
- Total employment
- Retail employment
- Industrial employment
- Other employment

The trip rates, the attraction equations and their development are described in detail in the WFRC/MAG Travel Model Recalibration Study - Methodology Report June 1995.

<u>It should be noted that trip generation is based on person trips and includes non-motorized trip modes such as walking and bicycling. The non-motorized trip estimates (zero emissions) are then removed from the trips to be assigned to the transportation network for emissions analysis.</u>

Step Two - Trip Distribution

The task of distributing the trips produced in each TAZ and attracted to each of the other TAZs, is referred to as trip distribution. In this step the trips "produced" and those "attracted" are linked geographically into origin-destination pairs.

Trip distribution is accomplished through gravity models for all but through trips. Gravity models represent the most common form of model in use for trip distribution. Inputs to the trip distribution process include 1)zonal productions and attractions from trip generation, 2) an impedance measure, 3) friction factors, and 4) trip table adjustment factors which are commonly called K-factors.

Trip distribution is accomplished for five trip purposes which are:

Home-Based Work
Home-Based Other (Non-work)
Non-Home Based
External - Internal
Commercial.

Trip generation creates productions and attractions for home based shopping, home based school, home based personal business and home based other. For trip distribution purposes the four home-based, non-work purposes are combined into a single home based other purpose.

For home-based work, home-based other, and non-home based the trips distributed are person trips which use some form of motorized transportation. For external - internal and commercial trips distribution is accomplished for vehicle trips or auto driver trips.

For all purposes other than home-based work, the impedance used in the gravity model is free flow auto travel times. Auto times are used because 99 % of the trips are made by automobile. Free flow times are used because the bulk of the trips are made outside of peak times. For work trips the impedance measure is congested times. *[The congested times are calculated by using the congested time from a 24 hour assignment. Volume to capacity ratios and congested speeds are calculated using a factor of 0.12 to convert hourly capacities to daily capacities. The result is a link speed that reflects peak travel times for both peak directions. The normal procedure for obtaining congested travel times is to use times based on the most recent comparable network. <u>This discussion of daily and hourly capacity will be deleted since the assignment will now be based on four time periods based on hourly capacities rather than a daily assignment</u>.]*

Terminal and intrazonal times are added to the travel time for each interchange prior to distribution.

Friction factors and other details of the development of the distribution model are described ~~in detail~~ in the WFRC/MAG Travel Model Recalibration Study - Methodolgy Report June 1995..

Step Three - Mode Choice

This step of the process determines the probable mode of travel taken by each traveling individual. It is commonly referred to as modal split. Members of the traveling public are assumed to choose from the following transportation modes for each trip: (1) take public transit; (2) drive alone in an auto, van or truck; (3) car pooling in similar vehicles; (4)

travel in a non-motorized mode such as walking or bicycle. The model assumes that their choices are based on the relative availability and attractiveness of each mode. Factors considered in the attractiveness of the mode include:

- Accessibility to mass transit
- Automobile ownership
- Costs required to use the mode
- Time required to use the mode
- Pedestrian friendliness

The cost variables represent "out of pocket" costs, including public transit fares, the price of gasoline, parking and a mileage rate for driving. Time variables include time spent waiting for transit, time transferring between routes, or time spent driving and parking the car in order to reach the final destination. The mode choice factors are arrayed in an equation that estimates the probability of each traveler selecting each mode, given the characteristics of both the mode and the traveler.

The model used is a nested logit model. A logit model is a mathematical device that measures the likelihood of choosing one of two options. The choice may be based on any number of factors such as travel time, cost, wait time, transfer time, parking time, and automobile availability; but the result must be one of two choices. In order to represent more than two choices, the logit models must be nested. The model incorporates a series of logit models to estimate the split between highway and transit as well as subsets of transit demand and highway auto occupancy. The output of the mode choice model is a series of 24-hour person-trip tables by trip purpose and mode.

Estimation of VMT requires that the auto mode trips be converted to vehicle trips. In addition the trips are broken down into the four time periods. The factors used to convert to vehicle trips and the time period break down are unique to each trip purpose and urbanized area. the factors are applied to each trip table resulting in a table of vehicle trips by time period.

Step Four - Traffic Assignment (Choice of Route)

The final step in the simulation of travel behavior is to determine the route travelers choose to reach their destinations. This step, known as traffic assignment, tells us how many vehicles will travel on each of the road segments, known as links. To perform this step, the computer model selects the best "path" through the highway or transit network for each type of trip, determining the shortest travel time between zones for each of the daily trips projected.

The highway "path building" process must take into account the actual capacities and speed of the road thus reflecting the degree of congestion. This is accomplished by the model running successive iterations of the assignment module, which adjusts the travel speed on each link according to the amount of congestion present. The process of iterative assignment used is the equilibrium process which iterates with the objective of reaching a condition where no traveler will be better off by changing routes. It simulates the effects of drivers selecting alternate routes to avoid congested roads. The congested speeds during the morning and afternoon peak travel times will be estimated as well as evening and mid-day speeds.

The travel model assigns trips to the network using an equilibrium assignment process. In this assignment process, link speeds are adjusted according to the capacity and assigned volume for each link resulting in new travel times. The new travel times are then used in a feedback loop to make a new distribution and assignment of trips. This process is repeated until travel times reach an equilibrium point at which there is no ability to improve travel path costs (time and distance) without degrading travel path costs in other parts of the network. The relationship between speed and congestion (volume/capacity ratio) is defined by the traditional “BPR” (Bureau of Public Roads) curves for each functional class as defined in the 1994 Highway Capacity Manual.

Validation of Model Results

An important part of MPO's ongoing modeling efforts is the validation of model results, testing model output against current conditions to ensure that the results are reasonable. In the validation process, MPO staff or its consultants compare both the intermediate and final results of the models with all available data for the region, including traffic counts, public transit passenger counts, and other survey results. Data from special surveys can be employed in this step.

Model Output to Emission Estimates

The four-step process produces the following:

- A report of traffic volumes, speed and volume to capacity ratio for each link in the network
- A set of trip tables showing origin and destination patterns by mode

Monitoring

The planning process includes activities to monitor the inputs to the travel models as well as traffic counts and transit ridership. The MPO's surveillance program is designed to identify deviations from the forecasts and evaluate their effects on long-range transportation needs.

Population estimates are received annually from the Utah Population Work Committee as well as employment estimates from the Department of Workforce Services. Traffic counting programs of UDOT and of the local and county highway agencies provide current traffic information. Special surveys and studies such as commuter parking surveys are conducted as needed to acquire and monitor particular events.

It is the intent of the MPOs to carefully monitor and maintain forecast data sets to ensure the accuracy of modeling assumptions used to develop this plan. Under a new monitoring plan currently being developed, the staffs of the MPO and its member agencies will compile appropriate tracking data.

Rural Area VMT Estimates

In accordance with the conformity regulations the February 1996 weekday and weekend factors were calculated from grouping various Automatic Traffic Recorder (ATR) data based on location, as well as Functional Class, to reconcile and calibrate the Vehicle Miles of Travel (VMT) based on the data contained in the 1996 Highway Performance Monitoring System (HPMS). The following tables will show the factors that were calculated for the UAM Model domain.

Weekday

For the Outlying and Rural areas in the modeling domain along with Interstate and Arterial functional classes there were 19 ATR’s grouped to calculate the February Weekday Factors. (Example: AADT from HPMS, Multiply by average factor below)

Rural Area Winter VMT Factors
AADT to Weekday

Location	Average
Modeled Rural	0.78
Rural Interstate	0.77
Rural Arterial	0.78

Weekend
For the Outlying and Rural areas in the modeling domain along with Interstate and Arterial functional classes there were 19 ATR’s grouped to calculate the February Weekend Factors. (Example: AADT from HPMS, Multiply by average factor below)

Rural Area Winter VMT Factors
AADT to Weekend

Location	Average
Modeled Rural	0.81
Rural Interstate	0.85
Rural Arterial	0.79

Mobile Source Emissions Inventory Protocol

Part II: Vehicle Emission Model

Vehicle Emissions Estimation Procedures

The speed data derived from the travel model and UDOT data for rural areas will ~~then~~ be used as input to the MOBILE5b model to determine emission rates for the various speed conditions. MOBILE5b reports emissions rates in grams/mile by vehicle classification (passenger cars, heavy duty trucks, motorcycles, etc.) as well as a composite emission rate for all vehicles. Emission rates are estimated ~~in grams/mile~~ for carbon monoxide (CO), nitrogen oxide (NOx), and volatile organic compounds (VOC). The MOBILE5b model input files will be set to reflect temperature conditions, fuel types, vehicle age distribution, vehicle inspection and maintenance (I/M) programs, and other parameters that may vary from one county to the next.

Thru trips and external/internal trips are 0.4% and 0.2% respectively of the regional trips. If these vehicles are not subject to I/M controls they could emit at a higher rate than vehicles in the urban area. Some of this marginal emission increase will be captured by modeling emissions from the rural portions of the study area that surround the four urban counties with I/M programs. Rural vehicle emissions will be estimated without I/M controls. The remaining marginal emissions are considered inconsequential.

Speed and functional class data will also be input to the PART5 model to determine particulate and sulfate emission rates in grams/mile.

Once the emission rates have been determined for the various speed conditions, these rates (in grams/mile) will be multiplied by the appropriate VMT for each time period and facility type producing a daily total of emissions in tons for each county. This total of county vehicle emissions will have subtotals for the four time periods and four functional classes previously described. Total county vehicle emissions then becomes the control total for spatial and temporal allocation within each county as discussed below.

Temporal Allocation of Emissions

~~The daily total of county vehicle emissions will then be allocated temporally and spatially~~. The temporal allocation begins with the subtotal of emissions by time period and then reduces this amount to an hourly emission value. The temporal allocation of vehicle emissions will be as follows:

AM Peak	-	3 hours, 6:00 am to 9:00 am
Midday	-	6 hours, 9:00 am to 3:00 pm
PM Peak	-	3 hours, 3:00 pm to 6:00 pm
~~Free Flow~~ Evening*	-	12 hours, 6:00 pm to 6:00 am

**During the ~~Free Flow~~ Evening time period XX% of the ~~Free Flow~~ Evening VMT occurs between the hours from midnight to 6:00 am~~.~~*

UDOT will estimate a daily VMT total for the rural areas. This daily VMT will be allocated temporally based on the percentage of VMT by time period in the urban areas. Assuming the relative insignificance of rural area vehicle emissions on the non-attainment areas, the simplifying assumptions made here regarding rural VMT by time period and rural speeds are considered appropriate.

Spatial Allocation of Emissions

The spatial distribution of emissions involves assigning emissions to a 2-km by 2-km grid cell based on the geographic location of each highway link. Since local class links in the model are not virtual representations of highway facilities, it will be assumed that local facility emissions are evenly distributed throughout the zone. Thus the ratio of total local facility emissions to zone area will be factored by the area of each cell captured within the traffic zone. In the rural areas, local and arterial facility emissions will be distributed according to population.

For spatial allocation of emissions, WFRC and MAG will provide to DAQ a geographic information system (GIS) data file (output from the travel model, known as a traffic assignment) containing traffic network link based data including coordinates, vehicle miles of travel, functional class, and ~~corresponding emission rate for~~ the functional class ~~and~~ speed for each time period in question. For each link there will be four VMT amounts corresponding to the four time periods. For each link there will also be four speeds according to the functional class of the link and each of the four time periods. For example, all arterial links will have the same four speeds for the AM-peak, midday, PM-peak, and evening time periods (See Figure 2 - Speed Classifications Used in Vehicle Emission Modeling).

Emissions rates for three secondary PM10 pollutants and up to seven primary PM10 pollutants will be determined. For each pollutant being analyzed there is a unique emission rate for each speed. Since there are four functional classes and four time periods, there is a possibility of 16 unique speeds and therefore 16 emission rates for each pollutant. Due to the redundant nature of the emission rates, the emission rate data will be provided in a separate "look up" table. ~~and 20 different emission rates representing each of the four time periods (speeds) and each of the five different pollutants (VOC, CO, NOx, SO4, and PM) will be given.~~

Weekend Vehicle Emissions

The process will be similar to that described above for weekdays except that Saturday and Sunday VMT factors by functional class and county will be applied. These factors will be provided by UDOT. ~~Free Flow~~ Evening conditions (emission rates) will be assumed for all Sunday traffic from 6:00 am to ~~11:00 pm.~~ midnight. Saturday traffic will be modeled as Mid-day from 9:00 am to 3:00 pm, and ~~Free Flow~~ Evening at all other times. Weekend traffic from ~~11:00 pm.~~ midnight to 6:00 am will be treated in the same manner as weekday traffic at these times except that the corresponding weekend VMT factors are applied.

DAQ has indicated that weekend base year emissions are not a significant part of the episode. Traditionally travel modeling has focused on weekday traffic. Given the lack of weekend data and limited demand for rigorous weekend traffic information, a simplified means of converting weekday traffic to weekend conditions is considered appropriate.

Primary Particulate Emissions

Appendix ~~A~~ B contains a sample input sheet obtained from DAQ for use in the PART5 model. This input sheet will be the prototype for PART5 model runs. Input speeds will be based on the 13 speed conditions described above, and corresponding to the four functional classes: freeway, ramp, arterial, and local.

Emission rates from the PART5 model will be evaluated separately and collectively. A separate evaluation of the five basic components of particulate emissions from PART5 will be useful in identifying potential control strategies. The five components are:

- exhaust particulates
- indirect SO_4*
- SO_2
- brake particulates
- tire particulates
- road dust.

(*Note: PART5 assumes that 12% of SO_2 emissions from vehicles form SO_4 particles. The UAM-AERO model may reveal a different conversion rate for SO_2 to SO_4. For this reason, both SO_2 and SO_4 emission rates will be tracked but care must be exercised that vehicle related SO_4 emissions are not double counted.)

Then the PART5 component emission rates will be evaluated collectively by totaling the emission rates by functional class and multiplying this rate by VMT as described ~~in the "Overview" section above~~ previously to obtain daily emission totals in tons.

~~The default silt load parameters included in~~ Salt Lake area silt load data used by DAQ in previous applications of the PART5 model will be used. These values in grams per square meter are: 0.10 for freeways and ramps, 0.14 for arterials, and 0.29 for local streets. Sonoma Technologies is conducting a literature research to determine silt load factors used in other localities. If a silt load factor is found which is believed to be more appropriate than the national default, the resulting impacts on the inventory will be evaluated and presented to EPA for approval. ***[DAQ study and Sonoma literature research on silt loads needs to be reviewed to determine if the above values are still valid].***

Secondary Particulate Emissions

MOBILE5ah vs MOBILE5b

MOBILE5b will be the vehicle emissions model used throughout the development of the SIP. MOBILE5b is approved by EPA for regulatory purposes. Some of the advantages of using MOBILE5b over MOBILE5ah are:

- allows modeling emissions for years 2020 to 2050
- greater flexibility in modeling hybrid I/M programs
- output data compatible with UAM requirements
- allows modeling of on-board vapor recovery equipment

There were some concerns about using MOBILE5b for the PM10 SIP while the Ozone and CO sections of the SIP are based on MOBILE5ah. According to EPA Region VIII officials, use of MOBILE5b for the PM10 SIP will not preclude the continued use of MOBILE5ah for conformity demonstrations with existing SIP documents.

During the development of the PM10 SIP it is anticipated that an ~~draft~~ EPA approved version of MOBILE6 will become available. Until that time, it is suggested that the PM-10 SIP development effort will proceed using MOBILE5b as the vehicle emissions modeling tool. As interim versions of MOBILE6 or other approximation tools may become available during the course of the PM-10 SIP effort, these will be considered for use to determine the extent of any change in emissions results between MOBILE5b and MOBILE6. The SIP preparation team will determine a proper course of action at that time.

Should MOBILE6 become a final tool per USEPA during the course of the SIP development process, then the SIP preparation team will determine an appropriate course of action to accomplish the completion of this SIP effort in final and approvable form, minimize reiterative modeling, and minimize or negate any associated negative impacts. ~~as soon as the test version of MOBILE6 is available, an analysis be made of the impacts this new model will have on vehicle emission rates. It is possible that MOBILE6 will not have any impact on the attainment demonstration or future conformity determinations. If this should be the case, the MOBILE5b based SIP would not need to be revised.~~

~~If, however, there is an impact to using MOBILE6 the PM10 SIP development team will then need to explore options to deal with this issue. One option is to continue development of the PM10 SIP with MOBILE5b with the expectation of updating the SIP in the very near future when a final version of MOBILE6 is available. A second option is to postpone the PM10 SIP until a final version of MOBILE6 is available. A third option is to compare emission rates between MOBILE5b and the test version of MOBILE6 and determine correction factors between the two. Then MOBILE5b emissions rates corrected to MOBILE6 values could be used in the SIP inventory process and verified when the final version of MOBILE6 is available. A final version of MOBILE6 is expected in the latter part of 2000. Other methods to estimate the impacts of MOBILE6 may be available.~~

NLEV and Heavy Duty Diesel Credits
The emissions model to be used is the EPA approved MOBILE5b with credits for the 2004 Heavy Diesel (HD04) program and the 2001 National Low Emitting Vehicle (NLEV) program. These credits are described in EPA's MOBILE5 Information Sheet 5 and 6 respectively and will be posted on the DAQ website (http://www.deq.state.ut.us/eqair/sip/pm10sip/transfer.htm) for reference.

TierII
It is anticipated that in the first few months of 2000 EPA will provide an Information Sheet modeling TierII credits. If EPA meets this schedule, the TierII credits will be included in the SIP development.

OBD
It is also anticipated that EPA will provide guidance on On-Board Diagnostics (OBD) credits prior to 2001. If EPA provides the necessary guidance to model the OBD credits prior to completing the projection inventory then the OBD credits will be included in the SIP development.

Diesel Inspection/Maintenance Programs
Salt Lake, Davis, and Utah counties each have diesel I/M programs. A smoke opacity test is performed on all vehicles registered in these counties regardless of vehicle weight or model year. MOBILE5b does not have the capability to model diesel I/M programs, so a post model adjustment will need to be made for diesel vehicles in these four counties. EPA will provide some guidance on credits for Utah's diesel I/M programs, expected to be in the 3% to 5% range. ~~At present, EPA does not recognize any credit for diesel testing.~~

I/M Programs
Since the I/M programs, temperatures, and other emission related parameters vary for each county, a separate MOBILE5b and PART5 input file will be created for each county in the study area. A description of the vehicle inspection and maintenance program (I/M) for each county in the study area is included in Appendix ~~B~~ C. For a complete explanation of the flags and parameters used in the MOBILE5b and PART5 models, refer to the corresponding User Guide posted on the

DAQ web site: http://www.deq.state.ut.us/eqair/sip/pm10sip/transfer.htm. The MOBILE5b input parameters will be set to correspond to these programs. A brief description of each county's I/M program is given below:

Weber (pre 1998)	basic two-speed idle, test and repair.
Weber (1998 and later)	basic two-speed idle, test and repair, technician training credits.
Davis (pre-1998)	basic two-speed idle, test and repair.
Davis (1998 and later)	hybrid program: "DC98", technician training credits
Salt Lake (pre 1998)	basic two-speed idle, test and repair.
Salt Lake (1998 and later)	ASM2, test and repair, technician training credits
Utah (pre 1998)	basic two-speed idle, test and repair
Utah (1998 and later)	basic two-speed idle, test and repair (credited as test only program), technician training credits.
Non-I/M Counties	including all or portions of: Box Elder, Cache, Carbon, Emery, Juab, Millard, Morgan, Rich, Sanpete, Summit, Tooele, and Wasatch Counties.

Davis County - In 1998 Davis County initiated a hybrid I/M program called "DC98". The plan takes advantage of "on-board diagnostics" (OBD) which is a standard feature of 1996 and newer vehicles. OBD is a self diagnosing electronic system which a technician can use to quickly identify any emission control devices that may be malfunctioning. The DC98 program requires vehicles 3, 6, and 9 years old to be tested at a centralized test facility using a loaded mode (dynamometer) test equivalent to the IM240 test. Model year 1996 or newer vehicles tested at the Center are was given the OBD test rather than the loaded mode test. All other vehicles were given a basic two-speed idle test at decentralized, "test and repair" stations.

Because the DC98 program is a hybrid program, it cannot be modeled in a single run with MOBILE5b. The DC98 program involves two different test types, plus a given vehicle receives a different type of test every three years. The Division of Air Quality conducted an elaborate modeling process of several MOBILE5ah runs and came up with composite emission rates for the DC98 program. This modeling process was greatly simplified by using a spreadsheet (DVFACTOR) devised by DAQ which places the composite emission rate between the rates calculated for a basic I/M program and that calculated for an enhanced IM240 program. This procedure was approved by EPA.

Salt Lake County - Salt Lake county employs a hybrid Acceleration Simulation Mode, two cycle (ASM2) I/M test. There is one small difference in the Salt Lake program that makes it a hybrid of the standard ASM2 test. The difference is that vehicle models 1989 or older are administered a less stringent anti-tampering inspection. For this reason, DAQ evaluations of vehicle emission rates in Salt Lake county has involved an elaborate combination of seven different MOBILE5ah runs resulting in a single composite emission rate. Upon closer inspection it was found that the composite emission rate differed very little from the "Option ASM2" and "Option ASM3" and "Option ASMp" runs as explained in the Technical Support Document for the 1997 Ozone SIP. The "Option ASM2" run was selected as the best single run corresponding to the composite emission rates. "Option ASM2" assumes minimal anti-tampering for all model years.

Utah County - The Utah County I/M Program is a decentralized test and repair network with a two-speed idle test on all gasoline vehicles 1968 model year or newer. The program was recognized by EPA as a test only network in 1998.

Effective February 29, 2000, the Utah County I/M Program will consist of a two-speed idle test on all gasoline vehicles of model years 1968 through 1995. OBD test will be done on all gasoline vehicles model year 1996 or newer. For the first year of OBD testing, if the vehicle passes the OBD test it will be given a certificate of compliance for registration purposes. If a vehicle fails the OBD test then it must pass the two-speed idle test in order to receive a certificate of compliance.

In the year 2001 the EPA will require OBD testing on all vehicles model year 1996 or newer. At that time, only those vehicles of model year 1996 or newer that are not OBD compliant will receive a two-speed idle test.

In the year 2000, the county will utilize remote sensing to identify gross emitters and for clean screening. Gross emitters are defined as vehicles that emit 5% CO or greater, as identified by remote sensing. These vehicles will be required to pass the appropriate vehicle emission cut-points using the appropriate test for their model year and weight. Vehicles that register 0% CO by the remote sensing equipment are considered clean and may be mailed a certificate of compliance for registration purposes.

Non-I/M Counties - Vehicles from the rural portion of the study area outside Salt Lake, Davis, Weber, and Utah Counties are not subject to emissions testing and compliance. Emissions from these vehicles will be modeled without an I/M program.

Since the rural areas are not covered by either MPO's travel modeling, the vehicle speeds will be assumed to be the posted speed limit. Specifically, freeway emissions will be modeled at 65 mph, arterial emissions will be modeled at 45 mph, and local traffic will be modeled at 20 mph. Ramp volumes will be included with freeway facilities in rural areas.

The four time periods used to describe traffic congestion and resulting variations in vehicle emissions in the urban areas do not apply to the rural areas. It is assumed that traffic congestion is not a factor in the rural areas, at least not to the extent that vehicle speeds and emissions would be significantly affected. Therefore, hourly vehicle emissions in rural areas will be treated as uniform in the model.

MOBILE5b Input Files

A summary of the MOBILE5b input parameters for each county is included in Appendix C. Input parameters that may change from one county to the next include: start year, first model year, last model year, ATP, RVP, cut points, stringency, waiver rate, compliance rate, fuel type, and vehicle model year data. For the attainment inventory, a specific episode in February 1996 will be mode3led. For the projection inventories the input files will be adapted to reflect changes in the local I/M programs, vehicle standards, and other parameters as they are evolve over time. Sample input files for MOBILE5b for each county are also included in Appendix C.

Temperatures

Temperature data will be obtained from the Division of Air Quality. For the attainment inventory, a daily minimum and maximum temperature for the February 1996 episode will be defined for each county. For the projection inventory the same minimum and maximum temperatures defining the February 1996 episode will be used.

Calculating different emission rates for temperature changes over the course of a day is not recommended. MOBILE5b is designed to produce daily emission rates for a region.

The temperatures to be used in each county for the attainment inventory and the projection inventories are outlined in Appendix D.

Vehicle Registration Data

The vehicle registration data describes the age of the on-road fleet in the area being modeled. It is recommended that the default vehicle registration data in MOBILE5b be used for all counties. Utah County has always used the default model year data. Salt Lake County vehicle registration data is old (1992), and it is uncertain how this data was extracted from Tax Commission records.

The current vehicle registration data collected through the county I/M programs is not available for all counties, and what is available is not complete for all vehicle classes. There also appears to be some discrepancy in distinguishing “LDGT1" and “LDGT2" type vehicles in the county data.

Another consideration is the advent of MOBILE6. This new emissions model employs a more detailed vehicle classification which could compromise reliance on local vehicle registration data.

VMT Mix

The VMT mix describes how much a particular vehicle type is used. The national default VMT mix contained in MOBILE5b (or MOBILE6 as the case may be) will be used.

RVP

Although RVP varies somewhat over the course of a year and by individual counties, winter RVP is always greater than the 11.7 psi maximum recognized by the MOBILE5b model. The majority of the winter months (November, December, and January) the state mandated maximum of 12.1 psi applies. The 12.1 psi value will be used in the model with the understanding that the MOBILE5b model will default to 11.7 psi.

Appendix A

Table of Resources

Table of Resources

Travel Model	WFRC and MAG Regional Travel Model as it exists on March 1, 2000
	WFRC/MAG Travel Model Recalibration Study - Methodology Report, June 1995
Vehicle Emissions Model (primary)	PART5
Vehicle Emissions Model (secondary)	MOBILE5b
Socio-Economics	1995 Surveillance of Socio-Economic Characteristics Report
	2000 Economic Report to the Governor
Trip Rates	1993 Home Interview Survey
VMT Mix	MOBILE5b default
Vehicle Registration	MOBILE5b default
Silt loads	Prescribed by DAQ
Vehicle Miles of Travel	1996 UDOT Highway Performance Monitoring System
Highway Capacity	1994 Highway Capacity Manual
Functional Classification	Highway Functional Classification - 1989 by USDOT, FHWA
VMT Factors	1991-1993 Trafic Volume Report, UDOT, June 1994

Appendix B

Sample Input File for PART5

PART5 Sample Input File

```
2020 LRP-SLCo Winter PM10;avg speeds;0.288-local silt loading;yr 2020
1    :VMFLAG (default VMT mixes)
1    :MYMRFG (default mileage accumulation rates & registration)
2    :IMFLAG (Inspection and maintenance)
1    :RFGFLG (2 to apply reformulated gasoline effects, 1 not to)
3    :OUTFMT (indicates type of output format, 3 text format)
2    :IDLFLG (2 to print, 1 not to print idle emission factors)
2    :SO2FLG (2 to print Gaseous SO2 emissions, 1 not to print them)
1    :PRTFLG (determines which pollutants to print out, 1 all pollutant)
1    :BUSFLG (1 do not print alternative bus cycles emission factors)
2 1996 2 65.0    : region, year, speed cycle, speed
05.7 0.1    2    : unpaved silt%, ind. silt g/m^2, WHEELFLG
76               : number of precip. days
Freeway Free Flow          :scene name
10.   -- Particle size cutoff
6000
04
2 1996 1 36.5    : region, year, speed cycle, speed
05.7 0.1    2    : unpaved silt%, ind. silt g/m^2, WHEELFLG
76               : number of precip. days
Freeway Congested Flow     :scene name
10.   -- Particle size cutoff
6000
04
2 1996 2 34.0    : region, year, speed cycle, speed
05.7 0.14   2    : unpaved silt%, ind. silt g/m^2, WHEELFLG
76               : number of precip. days
Arterial Free Flow         :scene name
10.   -- Particle size cutoff
6000
04
2 1996 1 17.6    : region, year, speed cycle, speed
05.7 0.14   2    : unpaved silt%, ind. silt g/m^2, WHEELFLG
76               : number of precip. days
Arterial Congested Flow    :scene name
10.   -- Particle size cutoff
6000
04
2 1996 1 20.0    : region, year, speed cycle, speed
05.7 0.29   2    : unpaved silt%, ind. silt g/m^2, WHEELFLG
76               : number of precip. days
Local                      :scene name
10.   -- Particle size cutoff
6000
04
```

Appendix C

Description of County Inspection and Maintenance Programs